119.53, 121.44, 121.68, 126.99, 134.46, 135.79, 136.17, 173.25; mass spectrum (CI, CH_4), m/e 259 (M + 1, 100%); high-resolution mass spectrum, m/e 258.1369 ($C_{15}H_{18}N_2O_2$ requires 258.1368).

2-Methyl-3-(methoxycarbonyl)-1,9-dimethyl-1,2,3,4-tetrahydro-9*H*-pyrido[3,4-*b*]indole (18a, 18b). N_a,N_b-Dimethyltryptophan methyl ester **17** (0.014 g, 0.057 mmol), acetaldehyde dimethyl acetal **10a** (0.010 g, 0.11 mmol), and trifluoroacetic acid (0.012 g, 0.11 mmol) were stirred for 12 days to provide **18a,b** as a dark oil (0.0155 g, 0.057 mmol, 100%); the cis/trans ratio was measured by ^1H NMR analysis to be 14:86 (c/t): ^1H NMR ($CDCl_3$) δ 1.52 (3 H, d, J = 6.9 Hz, $CHCH_3$ cis and trans), 2.47 (2.6 H, s, NCH_3 trans), 2.57 (0.4 H, s, NCH_3 cis), 2.90–3.18 (2 H, m), 3.62 (3 H, s), 3.63–4.04 (2 H, m including a singlet (3 H) at 3.72), 7.01–7.50 (4 H, m); mass spectrum (CI, CH_4), m/e 273 (M + 1, 100%).

***trans*-2-Benzyl-3-(methoxycarbonyl)-1-phenyl-1,2,3,4-tetrahydro-9*H*-pyrido[3,4-*b*]indole (16b).** N_b-Benzyltryptophan methyl ester **11c** (0.308 g, 1.0 mmol), benzaldehyde dimethyl acetal **10b** (0.310 g, 2.0 mmol), and trifluoroacetic acid (0.228 g, 2.0 mmol) were stirred for 48 h to provide a dark yellow oil, which was flash chromatographed on silica gel (hexane/EtOAc, gradient) to provide a light yellow oil (0.375 g, 95%) whose proton NMR and IR spectra were identical with those of the trans diastereomer **16b**[4] obtained from the reaction of N_b-benzyltryptophan methyl ester (**11c**) and benzaldehyde in refluxing benzene.[4] No other products were observed in this reaction by TLC or from the NMR spectrum of the crude material.

Acknowledgment. We wish to thank the NIH (NS-22287) and the NIMH (MH-36644) for generous financial support. We also wish to thank Dr. Suzanne Wehrli and Frank Laib for the NMR and mass spectra, respectively. We also acknowledge helpful discussions with Carol Gorst and thank Anju Gupta for preparation of this manuscript.

Registry No. **7a**, 99708-04-0; **7b**, 81095-85-4; **8a**, 123050-53-3; **8b**, 123050-54-4; **8c**, 123050-55-5; **9a**, 123050-56-6; **9b**, 123050-57-7; **9c**, 123050-58-8; **10a**, 534-15-6; **10b**, 1125-88-8; **11a**, 7303-49-3; **11b**, 123003-67-8; **11c**, 73327-10-3; **11d**, 123003-68-9; **12a**, 50302-68-6; **12a** (R′ = CH_2Ph), 123003-76-9; **12b**, 75196-51-9; **12b** (R′ = CH_2Ph), 123003-77-0; **13a**, 123003-69-0; **13b**, 123003-70-3; **14a**, 93712-66-3; **14b**, 93712-66-4; **15a**, 123003-71-4; **15b**, 123003-72-5; **16b**, 123050-52-2; **17**, 123003-73-6; **18a**, 123003-74-7; **18b**, 123003-75-8; H-DL-Trp-OMe, 7303-49-3; $PhCH_2CHO$, 122-78-1.

Primary Polyfluoroallylic Alcohols. Preparation and Isomerization into 2-Fluoroacrylic Acid Fluoride and 1-Fluoro Vinyl Ketones

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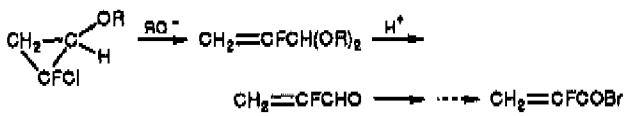
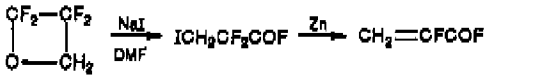
Received March 6, 1989

Alkyl and aryl 2-fluoroacrylic acid esters have been used as starting materials for number of coating agents, dental polymers,[1] and special glass.[2] These esters have been commonly prepared from 2-fluoroacrylic acid halides CH_2=CFCOX (X = Cl,[3] Br,[4] F[5]). The recent processes for having these intermediates involved the rearrangement

Scheme I



Scheme II

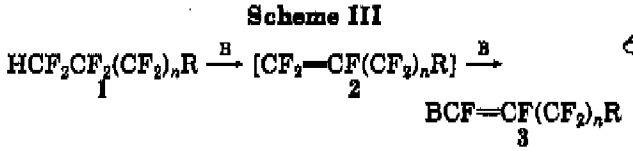


of an alkoxycyclopropane[4] (Scheme I) or the opening of and oxetane by a nucleophile[5] (Scheme II).

These two reactions brought great improvements over the previous method which used as starting material the very toxic 2-fluoroacetic derivatives.[6] The cyclopropane route needs nevertheless several steps, and the oxetane[7] is also toxic. Another possible way of obtaining 2-fluoroacrylic acid halides should be a rearrangement of 2-fluoroacrylic alcohols CXY=CFCH_2OH if these alcohols are available. The allylic rearrangements were already performed on secondary and tertiary fluoroallylic alcohols,[8] but not on a primary alcohol. The reason was certainly an absence of a practical method of preparation of these alcohols. Therefore we were searching a convenient method of obtaining primary polyfluoroallylic alcohols.

A few years ago, we showed that 1-H perfluoroalkyl chains are transformed into fluorinated olefins by action of strong bases like lithium dialkylamides[9] or organolithium reagents[10] (Scheme III).

Scheme III



This conversion was observed with alcohols $HCF_2CF_2(CF_2)_nCH_2OH$ when n was equal to 2, 4, or 6. The vinylic intermediate **2** was not isolated. This fluorinated olefin, activated by the electron-withdrawing difluoromethylene group, was steadily attacked by the organolithium reagent. However, the case of the alcohol $HCF_2CF_2CH_2OH$ **4** corresponding to n equal to zero, was not examined at that time. Recently we were asking ourselves what could be the reactivity of the intermediate olefin **5** which is not activated by an adjacent electronegative group. Is it possible to stop the condensation at the intermediate step **5** in order to get the allylic alcohol **7** after hydrolysis? (See Scheme IV.)

We report here that this transformation can be performed under controlled conditions of temperature and reaction time. Addition of methyllithium to the alcohol **4** in diethyl ether at 0 °C and stirring during 5 h at room temperature led, after hydrolysis, to a mixture containing 74% of **7**, 16% of **8**, and 10% of the starting material **4** as shown by an NMR analysis. If the condensation is allowed to go to completion when the addition is performed at room temperature the substituted allylic alcohol **8** can

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(2) Bloch, B.; Cavalli, C.; Charrier, D. German Patent (DOS) 2950490; *Chem. Abstr.* 1981, *94*, 16836.
(3) Boguslavskaya, L. S.; Tchouvatkin, N. N.; Morozova, T. B.; Pariteleava, I. Y.; Kartasiov, A. B.; Sineskov, K. P. *Zh. Org. Khim.* 1987, *23*, 1173. Heumuller, R.; Herbrechtsmeier, P.; Siegemund, G.; Groh, W. D.E.3 620 050 A1 (1987); *Chem. Abstr.* 1988, *109*, 205235a.
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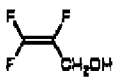
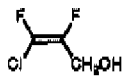
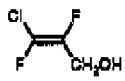
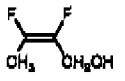
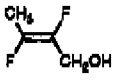
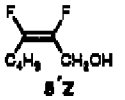
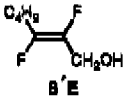
(8) Sterlin, R. N.; Yatsenko, R. D.; Knunyants, I. L. *Khim. Nauka i. Promy* 1958, *3*, 540; *Chem. Abstr.* 1959, *53*, 4195. Drakesmith, F. G.; Richardson, R. D.; Stewart, O. J.; Tarrant, P. *J. Org. Chem.* 1968, *33*, 286. Normant, J. F.; Foulon, J. P.; Masure, D.; Sauvêtre, R.; Villieras, J. *Synthesis* 1975, 122.
(9) Wakselman, C.; Nguyen, T. *J. Org. Chem.* 1977, *42*, 565.
(10) Nguyen, T.; Rubinstein, M.; Wakselman, C. *Synth. Commun.* 1983, *13*(1), 81.

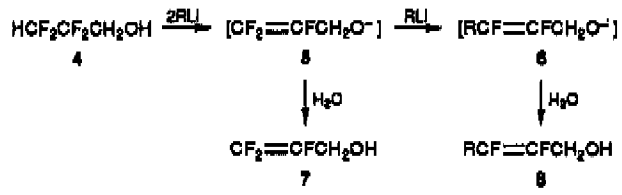
0022-3263/89/1954-5640$01.50/0

Table I. NMR Spectral Data of Polyfluoroallylic Alcohols XCF=CFCH$_2$OH

compounds	chemical shifts,[a] δ				coupling constants[b]						
	F	F	Y	CH_2CH	J_{FF}	$^3J_{FF}$	$^3J_{FF}$	$^5J_{FCH_2OH}$	$^4J_{FCH_2OH}$	$^3J_{FY}$	$^4J_{FY}$
 7	104	121	179	4.4	84	32	120	22	3		
 10E	104	141		4.4		14		22			
 10Z	122	152		4.4			138	22	2		
 8Z	126.5	147.5	2	4.2		8		24	4	20	2.5
 8E	145	161	2	4.3			134	25	5	19	
 8′Z	133	145	2.25 1.45 0.95	4.2		10		26		26	
 8′E	150	161	2.4 1.5 0.98	4.4			132	26	6	26	6

[a] Chemical shifts are expressed in ppm from TMS and $CFCl_3$ as external references. [b] Coupling constants are expressed in hertz.

Scheme IV



be obtained with 56% yield. Similar transformation of alcohol 9 into alcohol 10 has been also observed.

$$HCFClCF_2CH_2OH \xrightarrow{} CFCl{=}CFCH_2OH \xrightarrow{H^+} CH_2{=}CFCOF$$
9 10 11

Since alcohols 4 and 9 were easily available,[11,12] this process for having polyfluoroallylic alcohols appeared very attractive. One valuable development was the allylic rearrangement which occure steadily in acidic medium. From alcohol 7, 2-fluoroacrylic acid fluoride 11 was obtained in good yield. Likewise was for alcohol 10. In the case of 10, the superior ability of chlorine over fluorine as leaving atom was obvious. Allylic rearrangement occurred equally with alcohols 8; 1-fluorovinyl ketones 12 resulted (Scheme V).

Scheme V

$$RCF{=}CFCH_2OH \xrightarrow{H^+} CH_2{=}CFCOR \ (R = CH_3, C_4H_9)$$
8 12

Ketones of this type were prepared by a carbene route[13] or by organometallic condensations.[14,15] The present process was comparatively straightforward.

In conclusion, we are reporting a simple way to prepare primary polyfluoroallylic alcohols 7, 8, and 10, which use the easily accessible 3-hydropolyfluoropropanol 4 and 9 as starting materials. We have performed the allylic rearrangement of alcohols 7 and 10 into 2-fluoroacrylic acid fluoride 11, a valuable synthon in the preparation of 2-fluoroacrylic polymers. By extension of the method to alcohols 8 which were obtained by the same process, 1-fluorovinyl ketones 12 were prepared.

Experimental Section

^1H and ^{19}F NMR spectra were recorded on a Varian EM360L instrument, and chemical shifts were reported in ppm from TMS in δ scale for ^1H, from $CFCl_3$ in φ scale for ^{19}F. IR spectra were recorded on a Perkin-Elmer 1420 spectrometer. Elemental analyses were carried out in the Laboratoire Central d'Analyse of CNRS(Lyon). 3-H tetrafluoropropanol was purchased from TCI Tokyo, Japan, alkyllithium from Janssen Chimica Beerse Belgium, and chlorotrifluoroethylene from Matheson Oevel Belgium.

Trifluoroallylic Alcohol, 7. To a solution of alcohol 4 (20 g, 151 mmol) in 20 mL of anhydrous diethyl ether was added dropwise, at 0 °C, 320 mmol of methyllithium (1.2 M solution in ether); over a period of 1 h, the temperature was allowed to reach room temperature. Stirring was continued for 5 h; afterward the reaction flask was again cooled to 0 °C. Concentrated HCl

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(12) Franti$\check{s}$ek, L.; Simek, S. *Collect. Czech. Chem. Commun.* **1970**, *35*, 1752.

(13) Buddrus, J.; Nerdel, F.; Hentochal, P. *Tetrahedron Lett.* **1966**, 379. Molines, H.; Wakselman, C. *Tetrahedron* **1976**, *32*, 2099. Bessière, Y.; Savary, D. N. H.; Schlosser, M. *Helv. Chim. Acta* **1977**, *60*, 1739. Blanco, L.; Rousseau, Cr. *Bull. Soc. Chim. Fr.* **1985**, 455.

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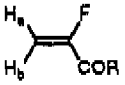
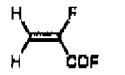
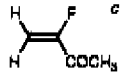
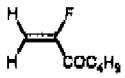
Table II. NMR Spectral Data of (1-Fluorovinyl)carbonyl Compounds 11 and 12



compounds	chemical shifts,[a] δ				coupling constants[b]			
	H_a	H_b	F	R	$^2J_{HH}$	$^3J_{FH_a}$	$^3J_{FH_b}$	J_{FR}
 11	5.6	6	−117	+14		12	46	18
 12	4.9	5.4	−116	2.3	4	17	46	3
 12′	5.1	5.65	−117	2.7 1.65 0.95	3	17	48	2

[a] Chemical shifts are expressed in ppm from TMS and $CFCl_3$ as external references. [b] Coupling constants are expressed in hertz. [c] These characteristics were in agreement with those given in the literature.[18]

(18 mL) was carefully added, and the pH was adjusted to 6 or 7. The solution was left for the night, and then the organic phase was separated, washed, and dried over magnesium sulfate. Diethyl ether was distilled off, leaving a crude oil which was flash distilled to give a clean liquid (bp 60 °C, 100 Torr; 17 g). By introduction of a known quantity of $CFCl_3$ in a sample of the distillate, one can evaluate the ratio of different fluorinated compounds obtained as in the following: 74% of 7, 16% of 8, and 10% of 4. Purified alcohol 7 was obtained by a second distillation in the presence of hydroquinone (bp 98 °C, 12.5 g, yield 74%). The ^1H NMR and ^{19}F NMR data of 7 are found in Table I. Anal. Calcd for $C_3H_3F_3O$: C, 32.17; H, 2.70. Found: C, 32.34; H, 2.75.

3-Chloro-2,3-difluoroallylic Alcohol, 10. The same process applied to a solution of alcohol 9, $CHClFCF_2CH_2OH$ (10 g, 68.4 mmol), in 10 mL of anhydrous diethyl ether, and 127 mmol of methyllithium, gave a crude distillate (bp 90–95 °C, 125 Torr; 7.8 g) from which alcohol 10 (bp 116 °C; 5.7 g) was isolated as two isomers (*E*/*Z* equal to 45/55). Their ^1H NMR and ^{19}F NMR data are found in Table I. IR (CCl_4): 3300 (OH), 1780 cm^{-1} (CF=CFCl). Anal. Calcd for $C_3H_3ClF_2O$: C, 28.04; H, 2.35. Found: C, 28.18; H, 2.48.

3-Methyl-2,3-difluoroallylic Alcohol, 8. To a solution of 10 g (76 mmol) of alcohol 4 in 30 mL of diethyl ether was added dropwise with stirring 220 mmol of methyllithium. The stirring was continued overnight at room temperature. The solution was neutralized carefully and worked up as in the preparation of 7. A fractionation of the crude distillate gave 7 (1 g, 9 mmol) and 8 (4.6 g, 42.7 mmol, yield 56%) as a mixture of two isomers (*E*/*Z* equal to 80/20). We cannot separate these isomers by VPC through a column of SE30 heated to 130 °C. The ^1H NMR and ^{19}F NMR data of these isomers are found in Table I. IR (CCl_4): 3300, 3230 (OH), 1740, 1710 cm^{-1} (CF=CF). Anal. Calcd for $C_4H_6F_2O$: C, 44.48; H, 5.6; F, 35.18. Found: C, 44.77; H, 5.61; F, 34.12.

3-Butyl-2,3-difluoroallylic Alcohol, 8′. Similarly, a solution of 7 g (53 mmol) of alcohol 4, 70 mL of diethyl ether, and 180 mmol of butyllithium (1.2 M solution in hexane) gave 6.8 g of crude distillate, bp 70–80 °C (15 Torr), from which 5.4 g (36 mmol) of 8′ were isolated, yield 68%. The isomers *E*, bp 176 °C, and *Z*, bp 188 °C, were separated by VPC through a column of SE 30 heated to 160 °C. The ratio *E*/*Z* was 77/23. The ^1H NMR and ^{19}F NMR data of these isomers are found in Table I. IR (CCl_4): 3300, 3230 (OH), 1732 cm^{-1} (CF=CF). Anal. Calcd for $C_7H_{12}F_2O$: C, 56.05; H, 8.06; F, 25.33. Found: (*E*) C, 56.17, H, 8.13; F, 24.82; (*Z*) C, 55.87; H, 8.93.

2-Fluoroacryloyl Fluoride, 11. Into a distillation flask containing 10 mL of concentrated sulfuric acid were added dropwise with stirring 2.5 g (22 mmol) of alcohol 7. An exothermic reaction occurred. The volatile acryloyl fluoride 11 formed was distilled in vacuo (200 Torr) in a receiver cooled by a dry ice–acetone mixture. Obtained was 1.15 g (12.5 mmol), yield 55%.

Similarly, 4.5 g (35 mmol) of alcohol 10 gave 2.78 g (29 mmol) of 11. Yield 82%. The ^1H NMR and ^{19}F NMR data of 11 were in Table I. Treated by a solution of phenol in CH_2Cl_2 11 gave the known phenyl 2-fluoroacrylic acid ester 2.

Fluorovinyl Methyl Ketone, 12. A mixture of 2.4 g (18.9 mmol) of alcohol 8, $CH_3CF=CF-CH_2OH$, 10 mL of tetrachloroethane, 0.5 mL of concentrated sulfuric acid, and hydroquinone was heated for half an hour on an oil bath at ca. 100 °C; it was then distilled in vacuo to give a crude distillate, bp 60–80 °C (100 Torr), 7.2 g. It contains 14.5 mmol (evaluated by ^{19}F NMR) of ketone 12, which was separated by a second distillation in the presence of hydroquinone at room temperature under 15 Torr. Yield 1.3 g, 76%. The ^1H NMR and ^{19}F NMR spectra of 12 are in Table II. IR (CCl_4): 1730, 1710 (C=O), 1640 cm^{-1} (C=CF). These characteristics were in agreement with those given in the literature.[18]

1-Fluorovinyl *n*-Butyl Ketone, 12′. A mixture of 2.1 g (14 mmol) of alcohol 8′, *E* and *Z* $C_4H_9CF=CFCH_2OH$, 5 mL of CH_2Cl_2, 0.5 mL of concentrated sulfuric acid, and hydroquinone was heated for half an hour on an oil bath at ca. 100 °C and then distilled off in vacuo to give ketone 12′, bp 75–80 °C (160 Torr), 1.2 g (8.6 mmol), yield 61%. The ^1H NMR and ^{19}F NMR data of 12′ are in Table II. IR (CCl_4): 1710 (C=O), 1640 cm^{-1} (C=CF). Anal. Calcd for $C_7H_{11}FO$: C, 64.67; H, 8.33. Found: C, 64.00; H, 8.60.

Registry No. 4, 76-37-9; 7, 41578-52-3; (*E*)-8, 123028-47-7; (*Z*)-8, 123028-48-8; (*E*)-8′, 123028-51-3; (*Z*)-8′, 123028-52-4; 9, 28885-04-3; (*E*)-10, 123028-49-9; (*Z*)-10, 123028-50-2; 11, 60558-85-6; 12, 2372-98-7; 12′, 71150-92-0; CH_3Li, 917-54-4; C_4H_9Li, 109-72-8.

Trimethylsilyl Polyphosphate for Intramolecular Friedel–Crafts Cyclizations

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In connection with studies directed toward the synthesis of a novel class of DNA intercalating agents,[1] we needed to prepare a series of 9*H*-selenoxanthen-9-ones. The

(1) Presented at the 78th Annual Meeting of the American Association for Cancer Research, Atlanta, GA, May 1987; Abstract No. 1197. Berman, E.; Klohs, W.; Leopold, W. R.; Plowman, J.; Sercel, A. D.; Shillis, J.; Showalter, H. D. H.; Werbel, L. M. *Proceedings Am. Assoc. Cancer Res.* 1987, *28*, 302.

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(6) Huang-Minlon, J. Am. Chem. Soc., 68, 2487 (1946).
(7) Crystals exposed to an atmosphere of 50–60% humidity absorb water and produce a solution within 15–20 s.
(8) The authors are grateful to Dr. L. Altman for carrying out the measurements.
(9) A. Murray, III, and W. H. Langham, J. Am. Chem. Soc., 74, 6289 (1952).
(10) Compare with the value 138–140 °C reported in ref 4.

Functionalization of 1*H*-Perfluoroalkyl Chains

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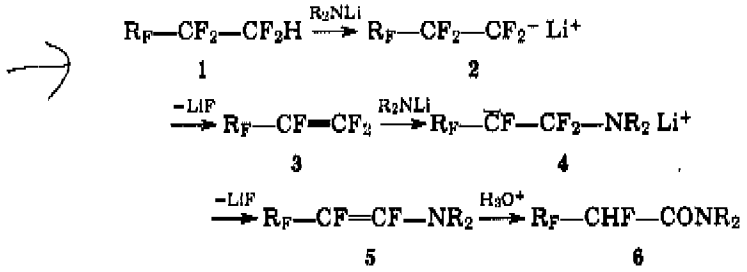
The terminal hydrogen of 1*H*-perfluoroalkyl chains is known to be extremely inert.[1] These compounds can only be halogenated[2] or oxidized[3] by a radical mechanism at a very high temperature. They are not affected by concentrated potassium hydroxide at 100 °C; however, a slow hydrogen–deuterium exchange has been demonstrated in methanol.[4]

We describe here the mild ionic reaction of lithium dialkylamide on compound 1 yielding the amide 6. The most probable reaction pathway is as follows:



The lithium dialkylamide initially reacts as a strong base, abstracting a proton from the CHF_2 group, then as a nucleophile which adds readily on the fluorinated alkene 3. This attack occurs on the difluoromethylene group and yields the most stable anion 4. Carbanions 2 and 4 produce respectively the perfluoroalkene 3 and the fluorinated enamine 5, both by loss of F^-. This enamine 5 may be isolated in aprotic media. For instance, $C_6H_5CH_2OCH_2CF_2CF_2CF{=}CFN(CH_2CH_3)_2$ (5d) was enough stable to be recovered unchanged after 1 month at 0 °C; its ^{19}F NMR spectrum shows a cis configuration (J_{FF} = 7 Hz). Using the lithium reagent (1–2 molar equiv) we have found that the reaction needs 2 molar equiv to go to completion and not any olefin 3 could be detected during the reaction by ^{19}F NMR on the crude reaction medium.

Amide 6 can be obtained from 1*H*-perfluoroalkyl chains containing a variety of functional groups such as ether, ketal, amide, etc. This type of compounds is readily available by a radical addition on tetrafluoroethylene.[5] The compounds with $R_F = -(CF_2)_nCH_2OH$ can be obtained commercially.[6] The results obtained with various substrates, using 2 equiv of lithium diethylamide in diethyl ether, are listed in Table I.

Bifunctional fluorinated compounds are relatively rare synthetic intermediates.[7] They are generally symmetrical. The functionalization of 1*H*-perfluoroalkyl chains by lithium dialkylamide constitutes a smooth access to symmetrical or unsymmetrical bifunctional fluorinated intermediates.

Experimental Section

^1H NMR spectra were recorded on a Perkin-Elmer R24 spectrometer with Me_4Si as internal standard. ^{19}F NMR spectra were recorded on a JEOL C-60HL spectrometer with $CFCl_3$ as external standard. Chemical shifts are given in parts per million. A downfield displacement is positive for proton, negative for fluorine. Coupling constants are in hertz. The s, d, t, q, m, usual abbreviations are used with the composite form dd, dt, dm, tt, ddd which are doublet of doublets, doublet of triplets, doublet of multiplets, triplet of triplets, and doublet of doublets of doublets. IR spectra were obtained on a Perkin-Elmer 167 spectrometer. Mass spectra data were obtained on a AEI MS 30 spectrometer.

We thank Mr. Foulletier (PCUK)[11] for a sample of 1*H*-perfluorohexane 1a. 1*H*,6*H*-Perfluorohexane 1b was prepared according to the method of Brace.[8] Compounds 1c and 1d were prepared starting from commercial (PCR)[11] 1*H*,1*H*,7*H*-dodecafluoroheptanol and 1*H*,1*H*,5*H*-octafluoropentanol. The first alcohol was oxidized following Joyce procedure[9] and the acid was transformed as usual in acid chloride, then in amide 1c. The second alcohol was transformed in ether 1d with benzyl bromide. Compound 1e was obtained by transketalization[10] of 7*H*-dodecafluoroheptanal prepared according to the method of Brace.[7] We thank Mr M. Rubinstein for technical assistance and the D.G.R.S.T.[11] for financial support.

Preparation of *N,N*-Diethyl-2*H*-decafluorohexanoic Acid Amide (6a). Into a 250-ml three-neck flask equipped with a mechanical stirrer, a condenser–drying tube system, and addition funnel fitted to provide an argon atmosphere was placed 5 g (15 mmol) of 1*H*-perfluorohexane in 30 ml of anhydrous diethyl ether. The flask was cooled at −10 °C with a CCl_4–dry ice bath. With stirring, a white suspension of lithium diethylamide [prepared by addition of 3.5 g (48 mmol) of diethylamine in 100 ml of ether on 31 mmol of a butyllithium solution in pentane at 0 °C] was added dropwise. After stirring the mixture for 1 h, it was acidified with 30 ml of 20% HCl solution. The mixture was extracted with diethyl ether. The organic layer was dried over $MgSO_4$ and filtered, and the solvent was evaporated under reduced pressure. The residue was distilled under vacuum to give 3.5 g of 6a: bp 95–96 °C (12 mm); IR (neat) 1660 cm^{-1} (amide); ^1H NMR ($CDCl_3$) 3.45 (q, 4 H, J = 7 Hz), 1.2 (t, 6 H), 5.5 (ddd, 1 H, J = 46, 16, 7 Hz); ^{19}F NMR ($CDCl_3$) 79 (3 t, 3 F, J = 11, 2 Hz), 124 (m, 2 F), 121 (m, 2 F), 117 (dm, 1 F, J = 280 Hz), 121 (dm, 1 F), 194 (ddd, 1 F); mass spectrum *m/e* (rel intensity) 351 ($M^{\cdot+}$, 67), 336 (M − CH_3, 96), 332 (M − F, 100), 322 (M − C_2H_5, 48).

Anal. Calcd for $C_{10}H_{11}F_{10}NO$: C, 34.15; H, 3.12; F, 54.10. Found: C, 34.06; H, 3.10; F, 54.23.

The same general procedure was used to prepare the other amides 6.

***N,N,N',N'*-Tetraethyl-2*H*,5*H*-hexafluorohexanedioic Acid Amide (6b):** bp 160–161 °C (0.1 mm); IR (neat) 1670 cm^{-1} (amide); ^1H NMR ($CDCl_3$) 3.4 (q, 8 H, J = 7 Hz), 1.2 (t, 12 H), 5.65 (ddd, 1 H, J = 45, 8, 14 Hz); ^{19}F NMR ($CDCl_3$) 122–123 (m, 4 F), 197 (dm, 2 F); mass spectrum *m/e* (rel intensity) 365 (M + $1^{\cdot+}$, 12), 345 (M − F, 15), 292 (M − NEt_2, 63), 264 (M − $CONEt_2$, 100).

***N,N,N',N'*-Tetraethyl-2*H*-nonafluoroheptanedioic Acid Amide (6c):** bp 169–170 °C (0.1 mm); IR (neat) 1670 cm^{-1} (amide); ^1H NMR ($CDCl_3$) 1.2 (2 t, 12 H, J = 7 Hz), 3.42 (q, 8 H), 5.65 (ddd, 1 H, J = 46, 12, 9 Hz); ^{19}F NMR ($CDCl_3$) 119–121 (3 m, 6 F), 117 (dm, 1 F, J = 310 Hz), 122 (dm, 1 F), 197 (ddd, 1 F, J = 46, 25, 12 Hz); mass spectrum *m/e* (rel intensity) 432 ($M^{\cdot+}$, 10), 404 (M − C_2H_4, 10), 344 (M − C_2H_4 − HF, 100).

***N,N*-Diethyl-2*H*,5*H*,5*H*-5-benzyloxypentafluoropentanoic

Table I

	Substrate		Amide	Yield, %
1a	$CF_3(CF_2)_3CF_2CF_2H$	6a	$CF_3(CF_2)_3CHFCONEt_2$	60
1b	$HCF_2CF_2(CF_2)_2CF_2CF_2H$	6b	$Et_2NCOCHF(CF_2)_2CHFCONEt_2$	60
1c	$Et_2NCO(CF_2)_4CF_2CF_2H$	6c	$Et_2NCO(CF_2)_4CHFCONEt_2$	40
1d	$C_6H_5CH_2OCH_2(CF_2)_2CF_2CF_2H$	6d	$C_6H_5CH_2OCH_2(CF_2)_2CHFCONEt_2$	60
1e		6e		60

Acid Amide (6d): bp 140–141 °C (0.1 mm); IR (neat) 1660 (amide), 1600, 1580, 1500 cm^{-1} (aromatic); ^1H NMR ($CDCl_3$) 7.3 (s, 5 H), 4.6 (s, 2 H), 3.95 (t, 2 H, J = 14 Hz), 5.55 (ddd, 1 H, J = 47, 15, 7 Hz), 3.35 (q, 4 H, J = 7 Hz), 1.1 (t, 6 H); ^{19}F NMR ($CDCl_3$) 121 (dt, 2 F, J = 10, 14 Hz), 122 (ddd, 1 F, J = 294, 15, 16 Hz), 127 (ddd, 1 F, J = 13, 7 Hz), 200 (m, 1 F); mass spectrum *m/e* (rel intensity) 353 ($M^{\cdot+}$, 43), 334 (M − F, 12), 297 (M − $2C_2H_4$, 10), 262 (M − C_7H_7, 42), 247 (M − C_7H_7 − CH_3, 100).

Anal. Calcd for $C_{16}H_{20}F_5NO_2$: C, 54.38; H, 5.70; N, 3.96. Found: C, 54.65; H, 5.55; N, 3.77.

The enamine **5d** (1-diethylamino-5*H*,5*H*-5-benzyloxyhexafluoropentene-1) was isolated from the crude reaction mixture by evaporation of the solvent before hydrolysis: ^{19}F NMR 117 (tt, 2 F), 122 (m, 2 F), 120 (dt, 1 F, J = 12, 7 Hz), 115 (dt, 1 F, J = 12 Hz).

***N,N*-Diethyl-2*H*,7*H*-7-ethylenedioxynonafluoroheptanoic Acid Amide (6e):** bp 139–140 °C (0.1 mm); IR (neat) 1660 cm^{-1} (amide); ^1H NMR ($CDCl_3$) 3.5 (q, 4 H, J = 7 Hz), 1.25 (t, 6 H), 3.95 (m, 4 H), 4.9 (ddd, 1 H, J = 34, 13, 6 Hz), 5.1 (m, 1 H); ^{19}F NMR 119–121–124 (m, 8 F), 197 (dm, 1 F); mass spectrum *m/e* (rel intensity) 405 ($M^{\cdot+}$, 10), 361 (M − OC_2H_4, 18), 346 (M − OC_2H_3, 100), 332 (M − $C_3H_5O_2$, 36).

Anal. Calcd for $C_{13}H_{16}F_9NO_3$: C, 38.53; H, 3.98; N, 3.46. Found: C, 38.68; H, 3.84; N, 3.46.

Registry No.—**1a**, 355-37-3; **1b**, 336-07-2; **1c**, 60895-94-5; **1d**, 60895-95-6; **1e**, 60895-96-7; **5d**, 60895-97-8; **6a**, 60895-98-9; **6b**, 60895-99-0; **6c**, 60934-65-8; **6d**, 60896-00-6; **6e**, 60896-01-7.

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Synthesis and Activity of 29-Hydroxy-3,11-dimethyl-2-nonacosanone, Component B of the German Cockroach Sex Pheromone

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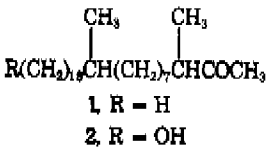
In a previous report,[1] we described a synthesis of 3,11-dimethyl-2-nonacosanone (**1**), an active component of the contact mating pheromone present in the cuticle of the female German cockroach (*Blattella germanica*). Recently, Ishii and co-workers, who first isolated and synthesized this substance,[2] have identified a closely related second component, 29-hydroxy-3,11-dimethyl-2-nonacosanone (**2**).[3] In connection with

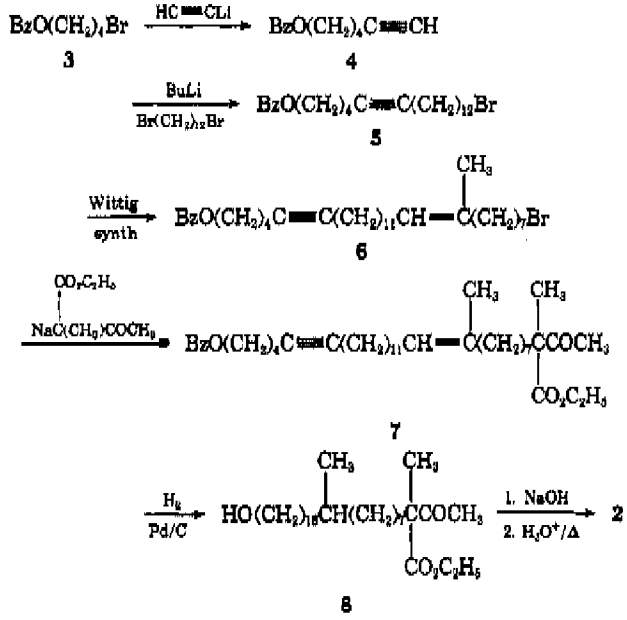


1, R = H
2, R = OH

studies on the behavioral responses of cockroaches to pheromones,[4] we undertook and now describe a synthesis of **2** together with some preliminary bioassays.

As shown in Chart I, the benzyl ether (**3**) of 4-bromo-1-butanol was used to assemble the terminal hydroxy chain.

Chart I



This derivative was selected because of its greater stability and convenience for removal compared to the alternative tetrahydropyranyl ether and because its distinctive spectral features made it especially useful for monitoring subsequent steps. The preparation of **3** was achieved in 88% yield by the phase-transfer catalyzed reaction[5] of 1,4-dibromobutane (5 equiv) with sodium benzyloxide. By alkylation with lithium acetylide (as the ethylenediamine complex), **3** was converted almost quantitatively into the acetylenic ether **4**. Monoalkylation of 1,12-dibromododecane (3 equiv) with the lithium salt of **4** then provided the acetylenic bromo ether **5** in 84% yield.

In the next step, a Wittig reaction of 9-bromo-2-nonanone[2] with the triphenylphosphorane derivative of **5** gave the olefinic bromo ether **6** as a mixture of *Z* and *E* isomers in 56% yield. Alkylation of **6** with ethyl 2-methylacetoacetate then furnished the required benzyloxy keto ester **7** in 91% yield. Finally, hydrogenation–hydrogenolysis of **7** gave the saturated hydroxy keto ester **8** (97% yield), mp 30–32 °C, which, when hydrolyzed and decarboxylated, afforded, in 71% yield from **8**, the desired hydroxy ketone **2** as a mixture of diastereoisomers, mp 41.5–43 °C.

Bioassay by antennation[1,2] showed that synthetic **2** readily evoked the characteristic precopulatory wing raising and 180°-turning response in isolated adult male German cockroaches. Male roaches isolated from their parent colonies were housed and tested in groups of five. In the tests their antennae were stroked intermittently (~10 s/min) with freshly ablated American cockroach (*Periplaneta americana*) antennae that had been dipped for 1–2 s into a carbon tetrachloride solution of the test substance and then allowed to dry.[6] All tests were performed at 24–25 °C during a period of 2.5–4.0 h into the dark phase of a 12/12-h photocycle.